^{13}C(^{6}Li,d) 1978Ar15

1970Be31: The ^{13}C(^{6}Li,d) and ^{13}C(^{7}Li,t) reactions were studied at the University of Pennsylvania tandem accelerator using 18-MeV ^{6}Li and 17-MeV ^{7}Li ion beams bombarding a self-supporting, 60±14 μg/cm^2 thick ^{13}C target. Reaction deuterons and tritons were momentum analyzed in a spectrograph over an angular range θ=3.75°−172.5°. Fifteen energy levels below E$_x$=8.5−MeV were deduced from the angular distributions. Transitions to negative-parity states at E$_x$=3.06, 3.85, and 4.55 MeV are the strongest when compared with those from the ^{12}C(^{7}Li,t) and ^{12}C(^{6}Li,d) reactions leading to the first K=0, ^{16}O rotational band. Strong transitions were also observed at E$_x$=7.38, (8.46,8.49), (8.87,8.95), and (9.14,9.20) MeV.

1970Go29: Beam of ^{6}Li/^{7}Li from the cyclotron of the Kurchatov Atomic Energy institute at E=25.6 MeV/30.1 MeV impinged on a self-supporting carbon foil (0.4 mg/cm^2, 75% ^{13}C isotope enriched). The reaction products were detected and identified with a ΔE/ΔX-E counter telescope. The energy spectra were analyzed using a multidimensional analyzer. The angular distributions of deutrons were obtained at θ=0°−45°. States at ^{17}O*(0,0.87,3.06,3.85,4.56,7.56,8.88 MeV) were observed. The group of levels in the energy range E$_x$=5.0-6.4 MeV were masked by the ^{12}C impurity in the target and not observed. The J$^\pi$ value of the ^{17}O*(7.56 MeV) state was determined as 9/2$^-$. The hypothesis of the weak binding of the four particles in the sd shell and of several holes in the p shell is confirmed.

1978Ar15: E(^{6}Li)=26, 29, and 34 MeV ion beams bombarded a 0.1-0.35 mg/cm^2 carbon film (70% ^{13}C, 30% ^{12}C) at the Kurchatov Insititute of Atomic Energy. Deuterons were measured by a ΔE/ΔX-E telescope that was placed at θ_{lab}=8° with respect to the beam direction. Alpha particles were detected by 4 surface-barrier detectors (≈100 μ thick). A series of excited states of ^{17}O with large reduced α-particle widths was found.

1978Cl08: An ion beam of ^{6}Li or ^{7}Li at E=34, 36 MeV, produced at the Florida State University/FN tandem Van de Graaff accelerator, impinged on 100 μg/cm^2 thick ^{13}C targets (enriched 99%). A ΔE-E telescope was used to detect particles with a subtended angle θ=0.2° with resolution 85 keV for tritons and 75 keV for deuterons. Angular distributions were measured at θ=5.0°−31.5°. Strongly populated excited levels of ^{17}O*(13.58 *2*: suggested J$^\pi$=11/2$^-$ or 13/2$^-$ or both,14.86,18.17,19.24 MeV) were observed.

1982Ta23: ^{13}C(^{6}Li,d), E=36,32,28 MeV; measured yield vs particle energy, $\sigma(\theta)$, fusion σ, breakup σ vs E; deduced reaction mechanism. Optical, simple breakup model analyses.

1984Ca39: The ^{13}C(^{6}Li,d)^{17}O*→α+^{13}C reaction was studied at the FN9 tandem Van de Graaff/the Centre d′Etudes Nucleaires de Saclay with an incident energy of E(^{6}Li)=34 MeV and a self-supporting, 157 μg/cm^2 thick ^{13}C target. Deuterons were detected by a DE-E Si telescope placed at θ_{lab}=10° and the coincident α-particles were recorded by two DE-E Si telescopes covering the angular range 20°<θ_{lab}<157.5°. The excitation energies of ^{17}O*(8.47, 8.92, 9.87, 13.6, 14.25, 14.95, 16.1, 18.3 and 19.6 MeV) were recognized.

1998Mu12: ^{13}C(^{6}Li,X), E(cm)=2.07-8.23 MeV; measured Eγ, Iγ; deduced partial, total fusion σ. Statistical model analysis, Optical model, Incoming Wave Boundary Condition model and one-dimensional Barrier Penetration model calculations.

2003Ka51,2003Ku03,2003Ku36: ^{13}C(^{6}Li,d), E=60 MeV; measured deuteron spectra, σ(E,θ); deduced spectroscopic factors, subthreshold state contribution, optical potential parameters.

2012La29: XUNDL dataset compiled by TUNL, 2012.

A beam of E=7.82 MeV ^{6}Li ions impinged on a 53 μg/cm^2 *99%* enriched ^{13}C target at the Florida State University accelerator facility. An array of five 5 cm×1 cm position sensitive Si detectors measured ^{16}O and deuterons from the reaction.

Three broad groups, corresponding to ^{17}O*(6356), ^{17}O*(7165,7248) and ^{17}O*(7378,7381) are populated in the reaction. Data are analyzed via an R-matrix analysis; the parameters of the higher-lying states are adjusted to reproduce values given in 2008He11. The Asymptotic Normalization Constant, ANC=$6.7^{+0.9}_{-0.6}$ fm^{-1} is deduced for the 6356 keV J$^\pi$=1/2$^+$ state. Discussion on the astrophysical reaction rate and impact of the E$_x$=6356 keV (α,n) subthreshold resonance is given.

Theory:

2003Ke10: ^{13}C(^{6}Li,d), E=60 MeV; analyzed σ(E,θ). ^{17}O deduced spectroscopic factors. DWBA and coupled reaction channels analysis, comparison with previous results, astrophysical implications discussed. See also (2018Ke03).

^{17}O Levels

E(level)†	J$^\pi$‡	L‡	Comments
0		3#	
871		1#	
3055	(1/2$^-$)	0	L: See also (1970Go29,2003Ka51,2003Ku03).
3843	(5/2$^-$)	2	L: See also (1970Go29,2003Ka51,2003Ku03).

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^{13}C(^{6}Li,d) 1978Ar15 (continued)

^{17}O Levels (continued)

E(level)†	Jπ‡	Γ‡	L‡	Comments
4554	(3/2⁻)		2	L: See also (1970Go29,2003Ka51,2003Ku03).
5085				
5216				
5697				Unresolved (1970Be31,2003Ka51,2003Ku03,2003Ku36).
5733				Unresolved (1970Be31,2003Ka51,2003Ku03,2003Ku36).
5869				Unresolved (1970Be31).
5939				Unresolved (1970Be31).
6356		83 keV *+9–12*	1@	Γ≈83 keV *+9–12*, Γ≈Γ_n (2012La29). ANC^2=6.7 fm^{-1} *+9–6* (2012La29). The results of (2003Ka51,2003Ku03,2003Ku36) indicate S_α(6.356)/S_α(3.055)=0.044. See also S_α=0.36-0.40 for N=4 (2003Ke10: calculated values in Table 3).
6862				
6972				
7165&	5/2⁻&	1.88& keV		Γ_n=1.88 keV Unresolved (2003Ka51,2003Ku03,2003Ku36).
7248&	3/2⁺&	340& keV		Γ_n=340.1 keV; Γα=0.14 keV Unresolved (2003Ka51,2003Ku03,2003Ku36).
7378&	5/2⁺&	0.42& keV		Γ_n=0.41 keV; Γα=0.011 keV
7381&	5/2⁻&	1.77& keV	(4)	Γ_n=1.77 keV Jπ: See also (9/2⁻)? (1978Ar15).
7559				
7576	9/2⁻a		4a	
7688				Unresolved (1970Be31,1978Cl08).
7757				Unresolved (1970Be31,1978Cl08).
8200				
8466	7/2⁺	7 keV *3*	3	Unresolved (1970Be31,1978Cl08).
8501				Unresolved (1970Be31,1978Cl08).
8687				
8885	7/2⁻	6 keV	4	Unresolved (1970Be31).
8897			4a	Unresolved (1970Be31,1978Cl08).
8967				Unresolved (1970Be31,1978Cl08).
9150				Unresolved (1970Be31).
9180	7/2⁻	3 keV	4	Unresolved (1970Be31).
9877				
9976	7/2⁺	107 keV	3	
10168	5/2⁺	138 keV	3	
11815				
12400				
13300?				
13.58×10^{3}b *2*	(11/2⁻,13/2⁻)ab	200 keV	6	Γ: From (1978Ar15). E(level): See also 13.6 MeV *1* (1978Ar15). Jπ: 13/2⁻ is preferred in (1978Ar15) based on expected systematics.
14.15×10^3‡ *10*	(9/2⁺,11/2⁺)	200 keV	5	Jπ: (11/2⁺) is slightly preferred in (1978Ar15).
14760				
15.1×10^3‡ *1*	(9/2⁺,11/2⁺)	0.38 MeV *15*	5	E(level): 15.0 MeV *1* at E(^{6}Li)=26 MeV, 15.15 MeV *15* at E(^{6}Li)=29 MeV. Γ: 0.37 MeV *15* at E(^{6}Li)=26 MeV, 0.40 MeV *15* at E(^{6}Li)=29 MeV. Jπ: 11/2⁺ is preferred in (1978Ar15).
15.95×10^3‡ *15*	(9/2⁺,11/2⁺)	4.0×10^2 keV *15*	5	Jπ: 9/2⁺ is preferred in (1978Ar15).
16.60×10^3‡ *15*	(11/2⁻,13/2⁻)		6	Jπ: 11/2⁻ is preferred in (1978Ar15).

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^{13}C(^{6}Li,d) 1978Ar15 (continued)

^{17}O Levels (continued)

E(level)[†]	J$^{\pi}$[‡]	Γ[‡]	L[‡]	Comments
17.10×10^3[‡] *15*	(11/2$^-$,13/2$^-$)		6	J$^{\pi}$: 11/2$^-$ is preferred in (1978Ar15).
19.60×10^3[‡] *15*	(13/2$^+$,15/2$^+$)	250 keV	7	J$^{\pi}$: 15/2$^+$ is preferred in (1978Ar15).
20.20×10^3[‡] *15*	(13/2$^+$,15/2$^+$)	250 keV	7	J$^{\pi}$: 15/2$^+$ is preferred in (1978Ar15).
21.2×10^3[‡]	(13/2$^+$,15/2$^+$)		7	J$^{\pi}$: 13/2$^+$ is preferred in (1978Ar15).
22.1×10^3[‡]				

[†] Observed in (1970Be31, 1970Go29, 1978Ar15, 1978Cl08, 1984Ca39, 2003Ka51, 2003Ku03, 2003Ku36). See nominal level energy values listed in, for example, (1978Cl08).
[‡] From (1978Ar15) except where noted.
[#] From (1970Go29,2003Ka51,2003Ku03).
[@] From (2003Ka51,2003Ku03).
[&] Populated in (2012La29) using values from (2008He11). Γ_n, $\Gamma\alpha$ are also from (2008He11).
[a] From (1970Go29).
[b] From (1978Cl08).

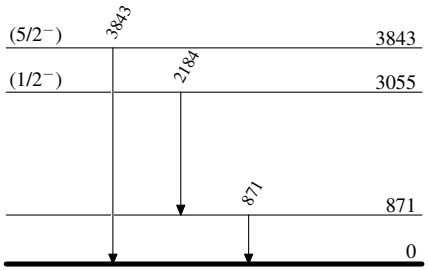
γ(^{17}O)

E$_\gamma$[†]	E$_i$(level)	J$_i^{\pi}$	E$_f$
871	871		0
2184	3055	(1/2$^-$)	871
3843	3843	(5/2$^-$)	0

[†] See (1998Mu12).

^{13}C(^{6}Li,d) 1978Ar15

Level Scheme



$^{17}_{8}O_9$